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groupings may produce the greater hydrolytic and highly specific actions observed with the natural lipases. That the simple linking together of animoacids in peptide-union is not sufficient to account for the actions is shown by the fact that peptides exert, if anything, a smaller hydrolytic action than the simple aminoacids.

Conclusion as to the Specific Character of Lipolytic Action. From the investigations briefly summarized in this paper it appears that the specific character of the hydrolytic actions produced by lipases is mainly due to two effects; first, the effect of the substrate on the enzyme in causing its coagulation or precipitation, and second, the effect of the enzyme on the substrate arising from the presence in the former of special groupings which may be similar to those contained in simpler nitrogenous substances which also bring about the hydrolysis of esters.

THE HYDRATION OF THE IONS OF CESIUM CHLORIDE DERIVED FROM TRANSFERENCE EXPERIMENTS IN THE PRESENCE OF RAFFINOSE

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The hydration of ions has attracted the attention of chemists for a number of years, and a large amount of evidence has been accumulated to show that ions are hydrated to a greater or less extent. One of the strongest pieces of evidence in favor of this view has been obtained by transference experiments in the presence of a non-electrolyte. If at the end of such an experiment the ratio of water to non-electrolyte has changed in the solutions around the electrodes, either the ions have carried water from one electrode-portion into the other, or they have carried the non-electrolyte in the opposite direction.

In a previous investigation by E. W. Washburn[1] the relative ionic hydrations of the chlorides of lithium, sodium, and potassium in 1.2 molal aqueous solution at 25° were derived by means of transference experiments in the presence of a suitable non-electrolyte as a reference substance. The object of the present investigation was to extend these data so as to include cesium chloride, which seemed desirable since there was much reason to believe that the cesium ion is the least hydrated of all the alkali ions.

The method employed consisted essentially in passing at 25° a measured quantity of electricity through a solution of cesium chloride containing enough raffinose to produce the desired rotation placed between a silver anode and a cathode consisting of silver covered with solid silver chloride. The apparatus was constructed so as to allow the separation of the portions around the electrodes from one another and from three middle portions. After the electrolysis the separate portions were carefully analyzed; the salt being determined by precipitation with silver nitrate, the raffinose polarimetrically, and the water by difference. The changes in content of the portions were computed on the assumption that the raffinose remained stationary during the passage of the current. Inasmuch as solutions containing 10% of raffinose have been prepared which had a specific conductance of 2×10^{-6} mhos (without 'correcting' for the conductance of the water), it is clear that the raffinose cannot conduct electricity appreciably either as an electrolyte or as a colloid.

The apparatus and experimental procedure were essentially the same as those employed in the previous work; but the concentration of the reference substance (raffinose) was reduced from 0.1 to 0.07 formula-weight per 1000 grams of water. This reduction in the concentration of the reference substance, while theoretically desirable, would tend to decrease considerably the accuracy in the measurement of the water transference, especially where, as in the case of cesium chloride, this transference is very small. This loss of accuracy was, however, compensated by employing a more sensitive polarimeter with a layer of solution one meter in length and substituting the *E* line (from a quartz mercury-vapor lamp) in place of the *D* line (from a sodium flame) previously employed. Without this great refinement in the polarimetric measurements the water transference in the case of cesium chloride could hardly have been detected, much less measured. The actual rotation measured in the polarimeter was about 50° and was reproducible to about 0.004°.

A practice run using sodium chloride as the electrolyte confirmed the previous work with this salt; thus this run gave 0.82 mols of water and 0.623 equivalents of chloride-ion transferred per faraday, as against 0.81 and 0.617 obtained in the previous work.

Two runs were made with 1.1 molal cesium chloride solutions. One of the runs was completely successful; but only the results obtained from the cathode portion of the second run were reliable. The number of mols of water transferred from anode to cathode per faraday were in the first run 0.33 and 0.39, and in the second run 0.28, giving a mean result of 0.33 mols per faraday. The values obtained for the number of equivalents of the anion transferred per faraday were similarly 0.506, 0.511, and 0.510.

The experimental data are presented in Table 1. The data given for the middle portion are also those for the original solution.

TABLE 1

First Experiment

	ANODE PORTION	ANODE MIDDLE	MIDDLE PORTION	CATHODE MIDDLE	CATHODE PORTION
Angle of rotation	48.671	48.228	48.131	48.116	47.452
Density at 25°	1.1105	1.1357	1.1357	1.1357	1.1642
Per cent raffinose	3.0320		2.9319	2.9310	2.8197
Per cent CsCl	12.077	14.772	14.770	14.750	17.713
Silver in coulometers	5.5048				5.5044
Weight of electrode portion	132.58				119.77
Grams H_2O transferred	0.30				0.36
Grams CsCl transferred	4.243				4.198
Faradays of electricity	0.05103				0.05102
Cation transference-number	0.494				0.489
Mols H_2O transferred per mol CsCl	0.64				0.80
Mols H_2O transferred per faraday	0.33	(Mean	0.36)		0.39

Second Experiment

Angle of rotation	55.865	55.137	55.137	55.127	54.421
Density at 25°	1.1152	1.1409	1.1409	1.1409	1.1689
Per cent raffinose	3.4653	3.3433	3.3433	3.3428	3.2208
Per cent CsCl	12.383	15.152	15.160	15.161	18.063
Silver in coulometers	5.4787				5.4787
Weight of electrode-portion	*				121.12
Grams H_2O transferred					0.25
Grams CsCl transferred					4.190
Faradays of electricity	0.05078				0.05078
Cation-transference-number					0.490
Mols H_2O transferred per mol CsCl					0.56
Mols H_2O transferred per faraday					0.28

* The anode residues were scorched in drying in this experiment, thus rendering uncertain the weight of the electrode portion.

The fact established by these experiments, independent of any hypothesis, is that the electrolysis of a solution of cesium chloride containing also raffinose at a low concentration is attended by a decrease in the ratio of the quantity of water to that of raffinose at the anode and a corresponding increase at the cathode. If now the probable assumption be made that the raffinose is not transferred by the current, the further conclusion is reached that there is a net transfer of water to the cathode, indicating that the cesium-ion is hydrated, and hydrated to a greater extent than is the chloride-ion. Moreover, a quantitative relation between the number of mols of water N_w^{Cs} on the cesium ion and the number N_w^{Cl} on the chloride ion can be derived from these results, as follows:

$$N_w^{Cs} = 0.67 + 1.03N_w^{Cl}.$$

For the purpose of comparison the corresponding relations previously obtained for the three other alkali chlorides[1] and for hydrochloric acid[2] at 25° at about 1.2 molal are here brought together with those for cesium chloride. The N_w's indicate the average number of water molecules carried by the ion indicated by the superscript as it moves through the solution. The values given are the means of the two results obtained at the two electrodes independently. The deviation of this mean from the two individual values is indicated in each instance by the term preceded by the ± sign.

$$N_w^{H} = 0.28 \pm 0.04 + 0.185 N_w^{Cl} \ldots\ldots (1)$$
$$N_w^{Cs} = 0.67 \pm 0.1 + 1.03 N_w^{Cl} \ldots\ldots (2)$$
$$N_w^{K} = 1.3 \pm 0.2 + 1.02 N_w^{Cl} \ldots\ldots (3)$$
$$N_w^{Na} = 2.0 \pm 0.2 + 1.61 N_w^{Cl} \ldots\ldots (4)$$
$$N_w^{Li} = 4.7 \pm 0.4 + 2.29 N_w^{Cl} \ldots\ldots (5)$$

From equations (2) and (3) we get the relation $N_w^{K} - N_w^{Cs} = 0.65$, which shows that the cesium ion carries on the average 0.65 less molecules of water than the potassium ion and is therefore the least hydrated of the alkali ions.

From equations (1) to (5) it follows, if we assume that the chloride ion is unhydrated, that the numbers of mols of water carried by the other ions are:

H^+, 0.3; Cs^+, 0.7; K^+, 1.3; Na^+, 2.0; Li^+, 4.7.

If we assume that the chloride-ion contains 4 mols of water, then the numbers contained in the other ions are:

H^+, 1.0; Cs^+, 4.7; K^+, 5.4; Na^+, 8.4; Li^+, 14.

Some experiments were also made with potassium nitrate; and, although the results were not quantitative, it was definitely shown that the water moved from the anode to the cathode in the case of this salt also.

All of the results given above are based upon the assumption that the raffinose remains stationary during the passage of the current. There is thus far no evidence indicating that this assumption is invalid to an extent which would appreciably affect the results. With the polarimetric apparatus at present at our disposal it will be possible to work with considerably smaller salt concentrations and to reduce the concentration of the reference substance as low as 0.01 molal in the case of lithium chloride solutions. By substituting trehalose for raffinose it will probably even be possible to use a considerably lower concentration than this and thus to remove all doubt as to the validity of the assumption in question. Work along these lines will be continued in this laboratory.

A more complete description of the research described in this paper will soon appear in the *Journal of the American Chemical Society*. A detailed description of it has already been printed as part of a doctor's thesis submitted by Earl B. Millard to the Graduate School of the University of Illinois.

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[1] Washburn, *J. Amer. Chem. Soc.*, 31, 322 (1909).

[2] Buckböck, *Zs. physik. Chem.*, 55, 563 (1906).

THE ORIGIN OF CORAL REEFS

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A Journey across the Pacific. A liberal grant from the Shaler Memorial Fund of Harvard University, supplemented by a subsidy from the British Association for the Advancement of Science, whose meeting in Australia during August I was invited to attend as a foreign guest, enabled me to spend the greater part of the year 1914 in visiting a number of islands in the Pacific Ocean with the object of testing the various theories that have been invented to account for coral reefs. Thirty-five islands, namely, Oahu in Hawaii, eighteen of the Fiji group, New Caledonia of which the entire coast line was traced, the three Loyalty islands, five of the New Hebrides, Rarotonga in the Cook group, and six of the Society islands, as well as a long stretch of the Queensland coast inside of the Great Barrier reef of northeastern Australia, were examined in greater or less detail. Darwin's theory of subsidence is, in my opinion, the only theory competent to account for the coral reefs there seen; thus my work leads to the same conclusion as that reached by several other recent students of this old problem. A full discussion of my observations will be published later, probably in the *Bulletin of the Museum of Comparative Zoology* at Harvard College. A brief statement of the chief results gained here follows.